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Applications Activities for NASA Flight Missions

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The NASA Applications Community

Purpose: This document outlines the need for applied science community of practice to be a part of the flight mission development life cycle from its inception through launch and operations. It further describes a process to identify, involve and eventually integrate the community as an entity that will apply mission science and data products in addressing critical societal issues.

1. Objective

The objective of applications activities for missions is to identify and engage with the community of practice for each NASA mission. Our objective is to ensure that users of NASA data are involved with the mission team, contribute to the mission and become powerful advocates for NASA and the earth science missions it carries out. Strategic engagement with key individuals and organizations will create strong partnerships that will both inform mission development from pre-Phase A through launch, and ensure powerful advocacy for the mission that will sustain it during periods of budgetary stress.

The Applied Science program at NASA emphasizes exploitation of the satellite remote sensing resources, scientific knowledge, and end-to-end system expertise for the benefit of society, ensuring that the strengths of the NASA Earth Science program have broad impacts. Our objectives in this document are to provide a strategy to ensure that we:

- Identify the community of practice for each mission and ensure flight missions are investing to produce products of maximal value for the community;
- Implement the NRC Decadal Survey and NASA Climate Architecture goals;
- Involve the community of practice into the mission development life cycle in the early stages of decision-making;
- Extract user requirements from the community for the mission; and
- Ensure a sustained interaction with the community of practice to maximize

impact of NASA Earth science investments.

Communities who may use new NASA data should be identified at the inception of the mission and should work closely with mission science and development teams to target specific mission data needs and requirements. Mission applications programs should focus on ensuring mission scientists have sufficient information about the needs of the scientific communities as well as the needs of the end user community so that the products that they develop are broadly relevant. Significant and sustained interaction and feedback between the NASA teams, the scientists and communities of data users from a diversity of arenas is necessary during the development of the products to ensure their ultimate usability.

Mission applications programs seek to engage the science data user community early in the pilot design process. This is accomplished by developing mission processes that will allow user feedback loops to be ingested by the science definition team and further ensure mission products are both useful and rapidly put into use. The Applied Sciences Program partners with public and private organizations on multidisciplinary ways that will apply products from NASA's environmental satellites and scientific findings into their decision-making activities and services, helping improve the quality of life and strengthen the economy.

2. Process of NASA Mission Development

There is no single avenue by which a mission is initiated. An original concept for a mission to obtain scientific data may come from members of the science community who are interested in particular aspects of an Earth science problem, or it may come from an individual or group, such as a scientific team working on a particular issue, who know of an opportunity to provide unique measurements. As a project matures, the effort typically goes through the phases listed in Table 1, from pre-Phase A formulation through to operations. Formal reviews are typically used as control gates at critical points in the full system life cycle to determine whether the system development process should continue from one phase to the next, or what modifications may be required.

The traditional process needs to be more balanced by recognizing and integrating the user community who will be a strong advocate of the science products, as shown in Figure 1. The integration of workshops and community feedback at defined phases of the mission enhances the development of the mission science while addressing specific political and scientific needs of the community. As a result the Applications Community becomes a cornerstone to the flight mission and science development.

Each mission should have its own applications strategy and implementation plan, which should involve a steady level of effort throughout the mission life cycles. Each mission will be tasked with identifying the user community, fostering relationships between the science and user community, developing communication strategies for

resolving data use/managing challenges and successfully linking mission products and requirements to specific/thematic user communities while facilitating the transfer of information and ideas through workshops and presentations. This work

Table 1. Descriptions of mission phases and applications activities relevant to each phase.

Mission Phase	Description	Application Activity	Work shop	Workshop Description
Pre-Phase A	Science Working Group (SWG) is established, which establishes level 1 requirements, science goals and prepares a preliminary scientific conception of the mission	Assessment of the *community of practice* Description of the intersection of mission requirements and the needs of known applications.	WS I	Present the "Community Of Practice" to mission team and define the scientific and policy need relevant to Mission Science objectives Workshop Report, involving the science community, the policy community and the community of practice to create optimal Level 1 requirements, with descriptions of trade-offs and required latencies for applications and optimal societal benefit
A Preliminary Analysis	The project creates a preliminary design and proof of concept specifying instrument design, orbit, altitude, ground data systems and other details. The publication of the preliminary costing plan marks the completion of Phase A.	Website establishment and database of user community individual begins. Application Plan written and posted to website	WS II	Feedback workshop of mission design study. Identification of potential Early Adopters. Data requirements discussed. Mission relevant policies identified. Identification of "important society decisions that will be made with mission science products"
B Definition	The definition phase converts the preliminary plan into a technical solution. Requirements are defined, schedules determined, and teams established around hardware. Science Definition Teams are competed and teams are chosen for each instrument and algorithm; the Science Team Leader is chosen.	Workshop conducted with targeted science communities to communicate key model, observation and applied science opportunities and requirements. Newsletters, articles and other communication strategies to expand the *community of potential.* Applications Working Group established, member of SDT designated as leader.	WS III + Focus Groups	Early Adopters Identified, Call for Proposals and collaboration with test data Thematic groups are created and Focus groups are planned
C/D Design/ Development		Annual workshop focused on results from organizations who are early adopters; description and provisions of test and cal/val datasets to the community of practice; conference presentations and papers; newsletters and journal articles on user interaction to expand the community of potential. Interaction with NASA HQ Applied Science prepare funding opportunities.	WS IV +Focus Groups	Early Adopter applied research presented, Mini focus groups feedback loops and articles in thematic journals. Publication of test Data feedback and results. Large Policy workshop to discuss the decision making process of existing Early Adopter research
Operations Mission Ops and Data Analysis	This phase includes flying the spacecraft and obtaining the data, processing, and delivering data to the community	Documenting decision support provided by mission data; newsletter, journal articles, conference presentations of applications of data; community interaction and support of data reprocessing and improvement; calibration/validation of data quality, format, issues.	WS V	Selection of Mission Thematic Leaders (Science and Policy) assigned to Science Team. Work into Applications Phase II-Coordination with Mission Operations and Support. -Documenting decision support provided by mission data through newsletters, journal articles, conference presentations of applications of data; -Community interaction and support of data reprocessing and improvement -Participation of calibration/validation of data quality, format, issues; -Evaluating and reporting on verified uses of mission data

can be done by science team members, an applications coordinator, or other personnel identified by mission management, but these individuals should be involved throughout the life of the mission. We recommend a constant level of effort for applications activities from pre-Phase A through to the end of the mission, with 1 to 1.25 FTEs per year.

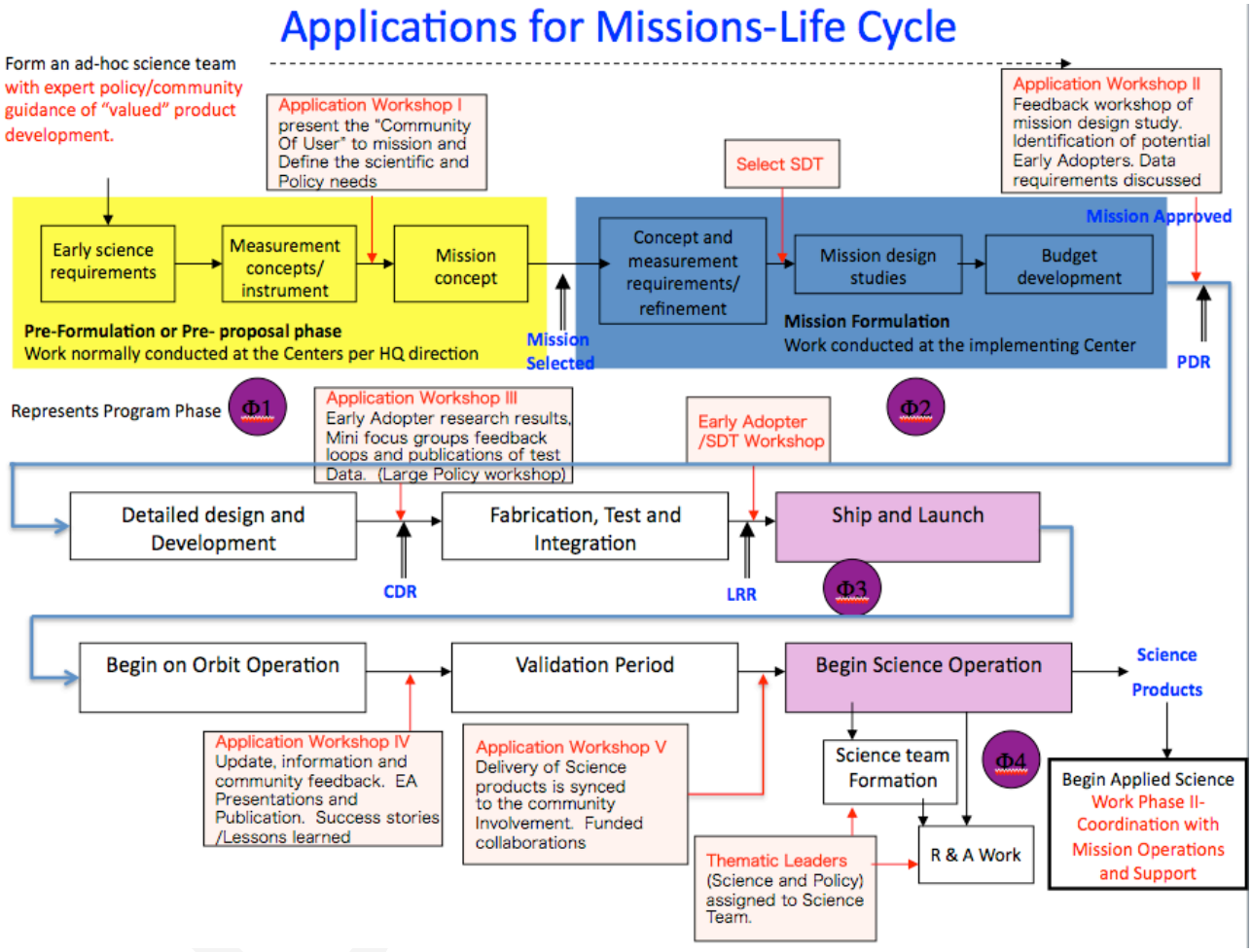

Figure 1. Applications Mission life cycle, showing workshops and major deliverables.

3. Applications Working Group

Each mission should establish an applications working group (AppWG) that works alongside instrument teams, algorithm working groups and other leadership structures set up by the Science Definition Team in Phase A. Through an integrative framework of feedback loops, research and collaborative opportunities, the AppWG is an important component of mission applications success. The AppWG is engaged in parallel within large communities of scientists, decision makers and individuals in organizations who use or manage the use of satellite remote sensing in their organizations. This larger group of users is termed the applications community of

practice (AppCOP), and a regular program of interaction and communication should be carried out throughout the pre-launch period to grow the community and ensure their involvement in events and opportunities for interaction with the mission.

3.1 Organization, functions, and responsibilities

The AppWG will be a group of 5-10 scientists and application specialists familiar with Earth science process studies to be potentially addressed by mission / instrument. The members will represent varied disciplines in the Applied Science areas of concentration or interest, or are interested in applying the mission data to a specific area of interest. Optimally, partial funding should be provided for members either by the mission or through NASA Headquarters as part of the science team membership. The lead of the AppWG is a member of the Science Definition Team (SDT) once it is selected, and the lead will report to the SDT chair along with the other working group leads.

The functions of the AppWG are:

- Be the technical interface between the science teams, mission team, and application end users
- Act as liaison between Applied Science program and end users
- Explore and gather information on potential applications and new end users
- Coordinate ROSES calls with NASA headquarters, engage with Applied Science Principal Investigators and their teams, and develop activities which engage the broader mission application community of practice (AppCOP)

Details of the functions vary with stage of mission, with different activities and levels of engagement as the mission moves from one stage to the next.

The responsibilities of the AppWG are to ensure that data and products needs of the end user community are included in all phases of the mission, and to coordinate workshops and other opportunities for engagement of the community of practice. Part of this work is to coordinate with the education and outreach activities of the mission, providing instrument and product information to application user community through various means – meetings, web site, brochures, etc. The AppWG will also participate in education and training activities in a variety of forums.

3.2 Applications Communities

Two main user groups in applications community are defined and categorized by their use of SMAP data in their operations and activities. These are:

- **Community of Practice** - *a group of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly.* In NASA Applications, we use the term to describe users who will partner to optimize their use of mission products as part of the mission development, testing and calibration/validation

- **Community of Potential** - users that are unfamiliar with the mission capabilities but have the potential to benefit from the products in their application or science

The engagement strategy for potential users of the mission data should follow a pathway from simple knowledge of the mission data characteristics and availability to actively using the data in the user system or process. Figure 2 shows the general strategy for engagement of users. Users will learn about the mission in a variety of ways, including those listed in the following sections. Users will be ready to use mission data when they engage in analysis, demonstration and have an understanding of the impact of the data on their own processes. It is not expected that all users will achieve readiness to integrate mission data by the time of launch, but those that do will be powerful examples for others to follow. In the pre-launch phase when only testbed simulations of mission datasets are available, the mission should work with user organizations to move as far along as possible in the cycle of engagement. Through this work the community of potential can be expanded.

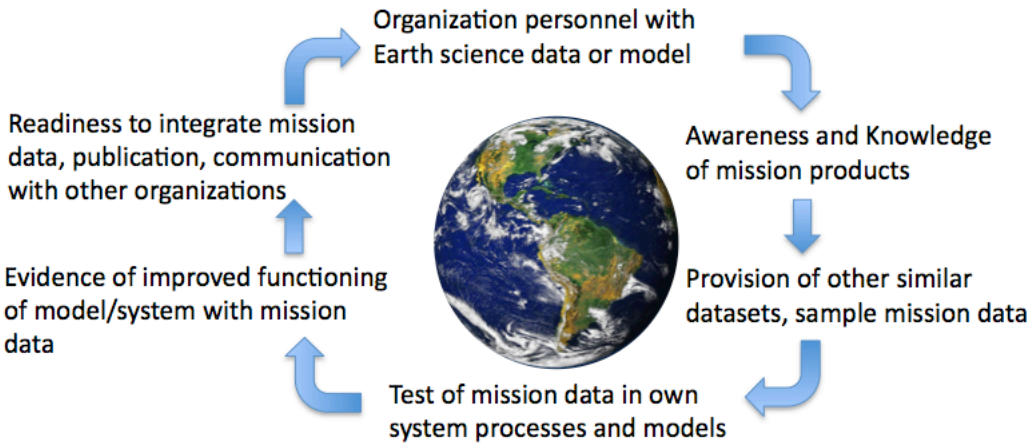

Figure 2. Flow of engagement of users from passive awareness to active use of mission data once it becomes available.

4. Early Adopters

Early Adopters, or those who have a direct or clearly defined need for mission data, and who have sufficient interest and/or personnel to demonstrate the utility of the data for their particular system or model, should be a key focus of the applications program. Early Adopters are a subset of the Community of Practice and should be given access to pre- and post-launch data streams and conduct applications demonstrations in collaboration with the science team.

The process through which Early Adopters are selected needs to be competitive and defined in Phase C, when the mission products are set and there is adequate test and validation and proxy data to provide to the community. The selection process may be through a competitive, peer-reviewed NASA announcement of opportunity as was done for the science definition team, or a more informal process. At a

minimum, the process should include a proposal, a selection committee and notification of selection. Memorandums of Agreement between NASA and the organization can be used to establish a formal relationship if the agreement is un-funded. Projects that the Early Adopters engage in should be specific and possible to complete before the launch of the mission.

5. Communication Strategies

The AppWG should provide support and communication between the community of practice and the mission science team. Outreach activities to science, government, educational, and layman communities should be coordinated with mission applications to ensure a clear path for interested users, from first contact to Early Adopter.

A broad program should be planned to engage with users, including:

- Regular AppWG meetings that will include participants from all possible users in each community
- Smaller disciplinary meetings hosted during other meetings or at sites as the opportunity arises
- Submit content in the form of articles, announcements or descriptions of the mission in newsletters, user forums or other venues where the user community may read them. This includes science and organization's newsletters that reach a broad user community.
- Mission science and applications organized sessions, papers and posters in widely attended remote sensing and environmental scientific meetings.
- The mission applications website should integrate and highlight all the ongoing activities from the applications programs, have articles, presentations and posters from meetings and planning documents. It will be routinely updated and provide a comprehensive overview of applications and potential methods of incorporating MISSION data. The website will have clear contact information and provide ways to get data, organize new projects and receive information materials for each application area listed above about what has already been done and what is effective.
- The applications program should target key international user groups that are mature, have solid missions and budgets, and can ensure that investments are made in new ways of using soil moisture information.

6. Applications Workshops

The primary objectives of Application Workshops are to develop the mission applications goals and objectives, further define and expand the user community, and increase the traceability to required observations and measurements. In Pre-Phase A workshops, the focus will be to define, identify and contact the communities that will benefit from mission products, understand application requirements and to combine them with the science requirements at inception. These requirements will flow into the design concept to ensure that the mission will provide rapid and useful

applications and response products.

The outcome of the workshop should be detailed in a report and include the following:

- Goals, objectives, and observation requirements
- Description of the Community of Practice
- Observation frequency and time period for particular applications
- Data products descriptions including latency
- Required ancillary data and infrastructure
- White paper(s) articulating lessons learned and the AppWG/SDT collective actions items to be implemented in the following mission phase.

Annual workshops held during Phase C/D are to be focused on Applied Science, where models and processes are described with regard to how they have been changed to incorporate the new data stream. Workshops can be community specific or broader, with multiple sessions focused on different communities. Early Adopters should play a central role in presenting projects that demonstrate the improvement in processes due to incorporation of mission data. These workshops should result in papers published in the peer-reviewed literature and a workshop report focused on the applied science resulting from the mission applications program.

During Phase C/D, smaller thematic or community workshops are biproducts of annual workshops can be held to bring together scientists and data users from within the user community (i.e., hydrology, ecology, climate science, etc.). They provide a detailed scientific perspective of societal needs at a high level which are usually unattainable in larger forums. The focus groups are an opportunity for a detailed community of users to describe specific research methodologies and modeling techniques within a defined space and working closely with mission SDT representative assigned to the Focus Group. Outcomes of these Focus Groups can generate improved methodologies through peer collaboration and SDT involvement and participation in the mission.

7. Deliverables by Mission Phase

We expect a steady level of effort for applications activities throughout a mission. Starting with the Pre-Phase A and going through operations, continual support will be required to maintain programs, build relationships, grow communities and organize workshops. Each mission should deliver the following:

<u>Pre-Phase A:</u>

- Assessment of the *community of practice*, and a description of the intersection of mission requirements and the needs of known applications.
- Workshop and Workshop Report, involving the science community, the policy

community and the community of practice to create optimal Level 1 requirements, with descriptions of trade-offs and required latencies for applications and optimal societal benefit.

Phase A:

- Applications Strategy and Plan for mission created and posted
- Web site established and database of user community individuals begun.
- Early Adopter solicitations and a well defined *communities of practice* (both science and policy)
- White paper from Pre-Phase A lessons learned

Phase B:

- Formation of the Applications Working Group and designated lead on the Science Definition Team
- Workshop conducted with targeted science communities to communicate key model, observation and applied science opportunities and requirements.
- Newsletters, articles and other communication strategies to expand the *community of potential*.

Phase C/D:

- Annual workshops, focused on applied science results from the early adopters;
- Description and provision of test and cal/val datasets to the community of practice;
- Communication: conference presentations and papers; newsletter and journal articles on user interactions to expand the *community of potential*.
- *Early Adopters* identified and cooperative agreements set up to target key integration goals.

Operations:

- Documenting decision support provided by mission data through newsletters, journal articles, conference presentations of applications of data;
- Community interaction and support of data reprocessing and improvement
- Participation of calibration/validation of data quality, format, issues;
- Evaluating and reporting on verified uses of mission data

8. Assessing benefits

The benefit of mission data on systems and processes for society can be difficult to assess. Benefits can be anything that is perceived to be a positive change in an individual or group's life. It is not limited to simple monetary changes. For example, improvements in human health, reductions in mortality, improvements to the ecosystem and the environment, and quality of life can all be regarded as benefits.

In order to measure the outcome and impact of a particular benefit, a mission applications program should seek to determine the improvement in the function of an application or system using statistical analyses to determine if outcome is real. In order to do this, a baseline must be put into place before the data are incorporated into the system or process, then a change can be measured that can clearly be attributed to the inclusion of the new data. Confounding effects, such as a significant change in effort, fundamental change in objective or goal of the process, etc, must also be taken into account. Thus, we propose that each mission choose a few key projects to set up a baseline and prepare to analyze the impacts of these processes.

The applied science program at NASA would also like to be able to monetize societal benefits where the benefits are tangible. There are a large number of potential measures and methods to convert tangible benefits into dollar costs. For example, the Department of Transportation (DOT) places a value on time for time lost waiting in congestion and there are numerous ways to value the human health impacts varying from standard costs of productive time lost (in terms of contributions to Gross Domestic Product (GDP)), cost of health care and treatment, and avoided loss of future earnings. In terms of identify potentially monetary values we will consider the following approaches:

- ***Market Values:*** There are numerous markets for many items that can be used to estimate the overall monetary value of outcomes.
- ***Federal Government Standard Monetary Equivalents:*** The Federal Government may have established or recognize a standard monetary value for the unit under analysis.
- ***Consider Industry Standards:*** There may be established standard monetary values for the unit under analysis, for example industry wage rate and standard costs for common operations.
- ***Develop Project-Specific Values:*** A new monetary value based on combining any of the above or developing unique values may also be possible.

Thus we have several approaches to evaluating the impacts of one or two applications that have incorporated mission data:

- Conduct a statistical analysis that provides support for documenting the outcomes of improvement of a model, process or analysis over the baseline;
- Describe the benefits of these improvements to society;
- If benefits are tangible, monetize these benefits using accepted and documented approaches.
- Conduct a small user driven pilot study where the application is at the forefront of the mission development-bringing “added value” to NASA products and research from inception and highlighting the integration of science for policy decision-making purposes from the beginning.

Recommendations

The use of data and understanding how NASA products can bring value to societal needs is an important part of NASA Applied Sciences Program goal. Applying scientific knowledge to practical problems begins with understanding the needs of the user. The decision-making processes which surround mission science and objectives should compliment the goals and objectives of the communities that intend to use mission-science information. By bridging mission science and mission applications we can demonstrate user inspired innovative uses and practical benefits of NASA Earth science data, scientific knowledge, and technology that will benefit society.